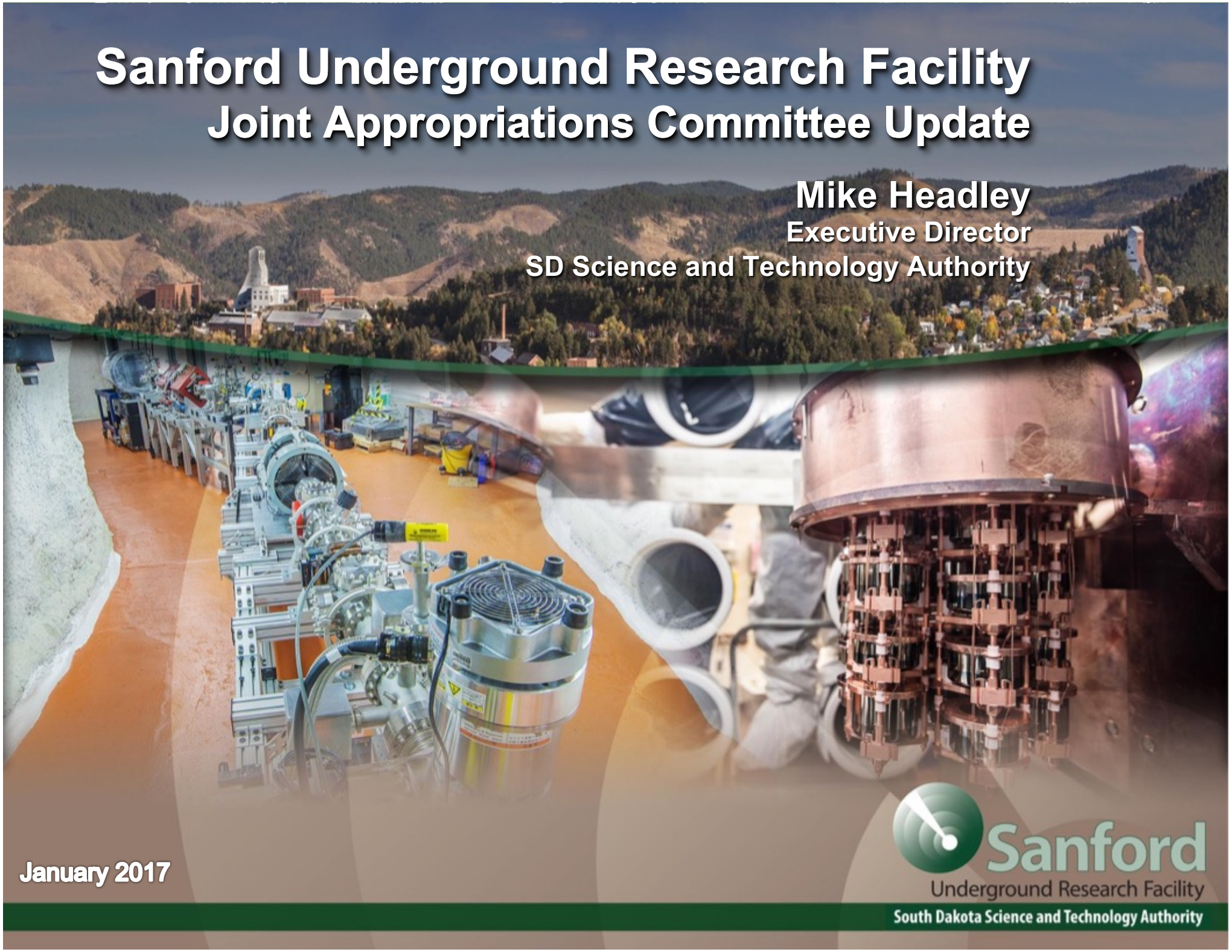
Sanford Underground Research Facility
Joint Appropriations Committee Update

Mike Headley
Executive Director
SD Science and Technology Authority



January 2017

Sanford Underground Research Facility
South Dakota Science and Technology Authority

SD FY2018 Major Goals

- Provide safe underground access and operate science facilities for our current experiments and support preparations for future experiments.
- Complete the Ross Shaft Rehabilitation Project to the 5000 foot level.
- Complete surface facilities for the LUX-ZEPLIN (LZ) Generation 2 Dark Matter experiment. Acquire xenon. Begin underground facility construction.
- Complete final designs for the Long-Baseline Neutrino Facility (LBNF) work planned for South Dakota. Begin early facility construction to start in 2017 in preparation for an excavation start in 2019.
- Support a strong education and outreach program based on our science.
- Advance strong partnerships with the South Dakota Universities, American Indian Tribes, State and Federal Agencies, and Industry Partners.

Budget Highlights

SDSTA budget outlined on pages 12-16 of Budget Briefing

- FY17 to FY18 budget changes
  - Overall budget increase of $1.3M and transition of 0.4 FTE to other funds.
  - Budget increases due primarily to purchases of xenon for the LUX-ZEPLIN (LZ) experiment, LZ facility construction, and interest payments on xenon loans.
  - No unused FTEs or special appropriation requests. No fee increases.
  - New Ross Shaft refurbishment contract put in place between Lawrence Berkeley National Lab and SDSTA in Jan 2016. Contracting responsibility then transitioned from LBNL to Fermilab in Dec 2016. Project to conclude in late 2017.
  - Dept of Energy (DOE) funded Sanford Lab operations contract transitioned from LBNL to Fermilab in Oct 2016. New 5-year operations contract expected in 2017.

- SDSTA workforce
  - 129 full time staff, 13 part time staff.
  - No major changes in SDSTA staffing anticipated.

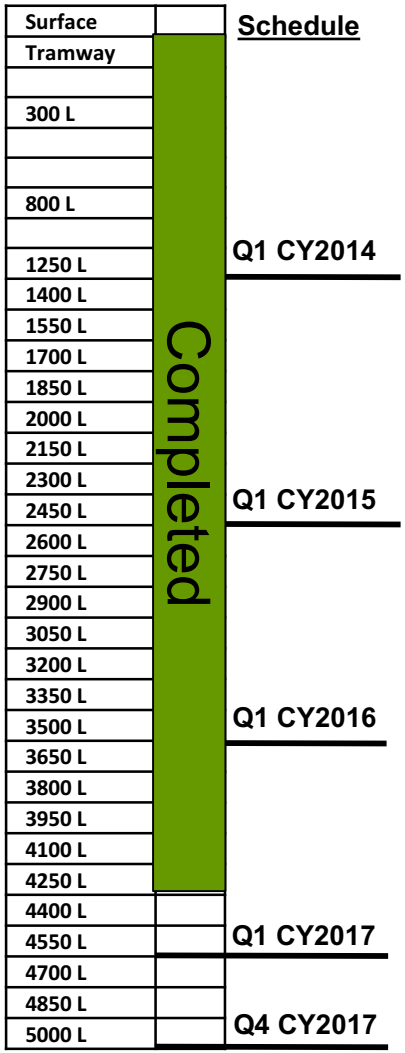
Federal Funding FY2017

Federal Contract / Project	Total $$
LBNL / SURF Operations	$14,748,459
LBNL / Ross Rehabilitation	$7,059,861
FNAL / Long Baseline Neutrino Facility	$1,754,498
LBNL / LUX	$161,616
LBNL / LZ	$382,062
Total	**$24,106,496**

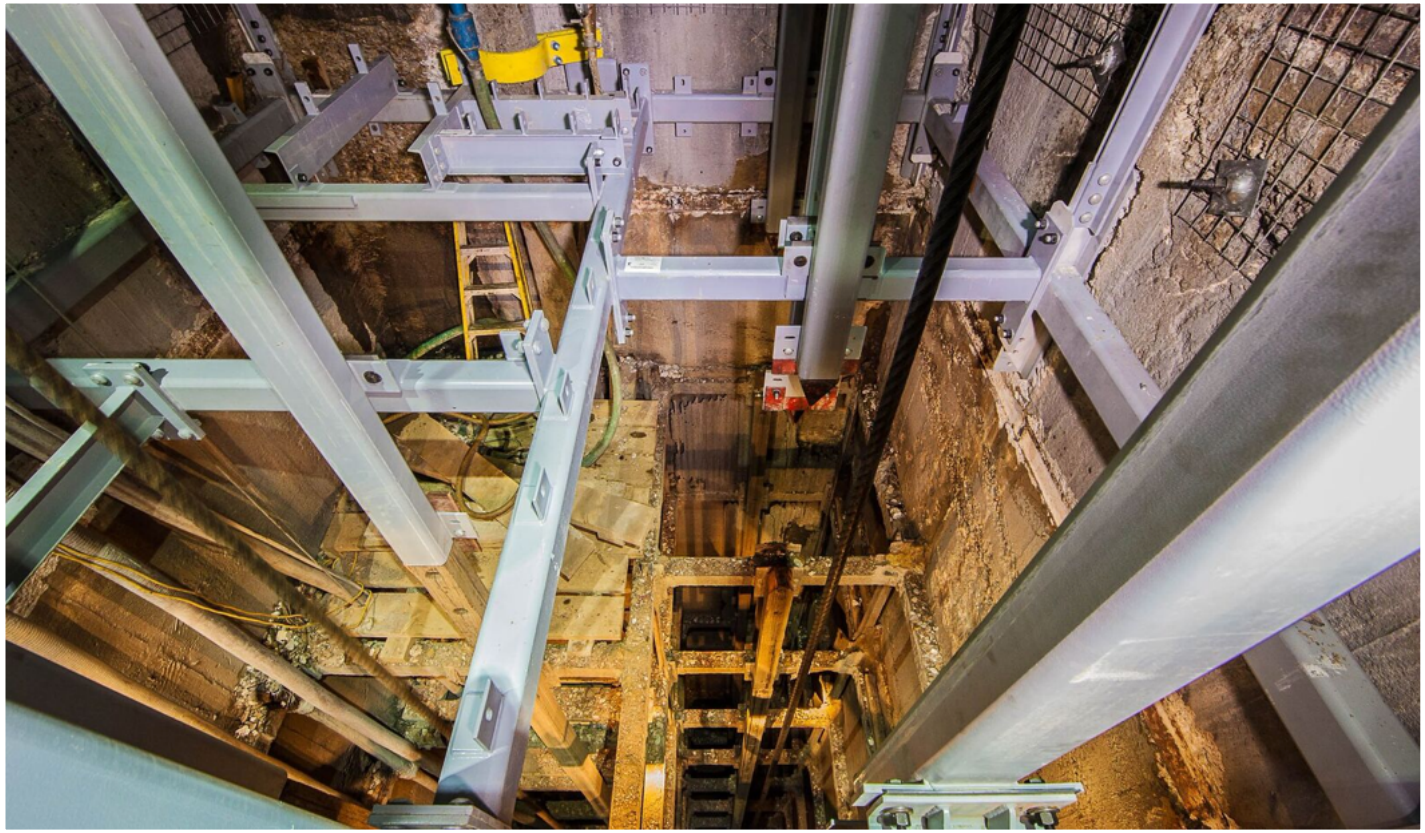
- Total does not include LBNF Final Design contracts that are expected in January, $3.6M.

Ross Shaft Refurbishment Update

4,402 feet down from surface (85% completed overall)

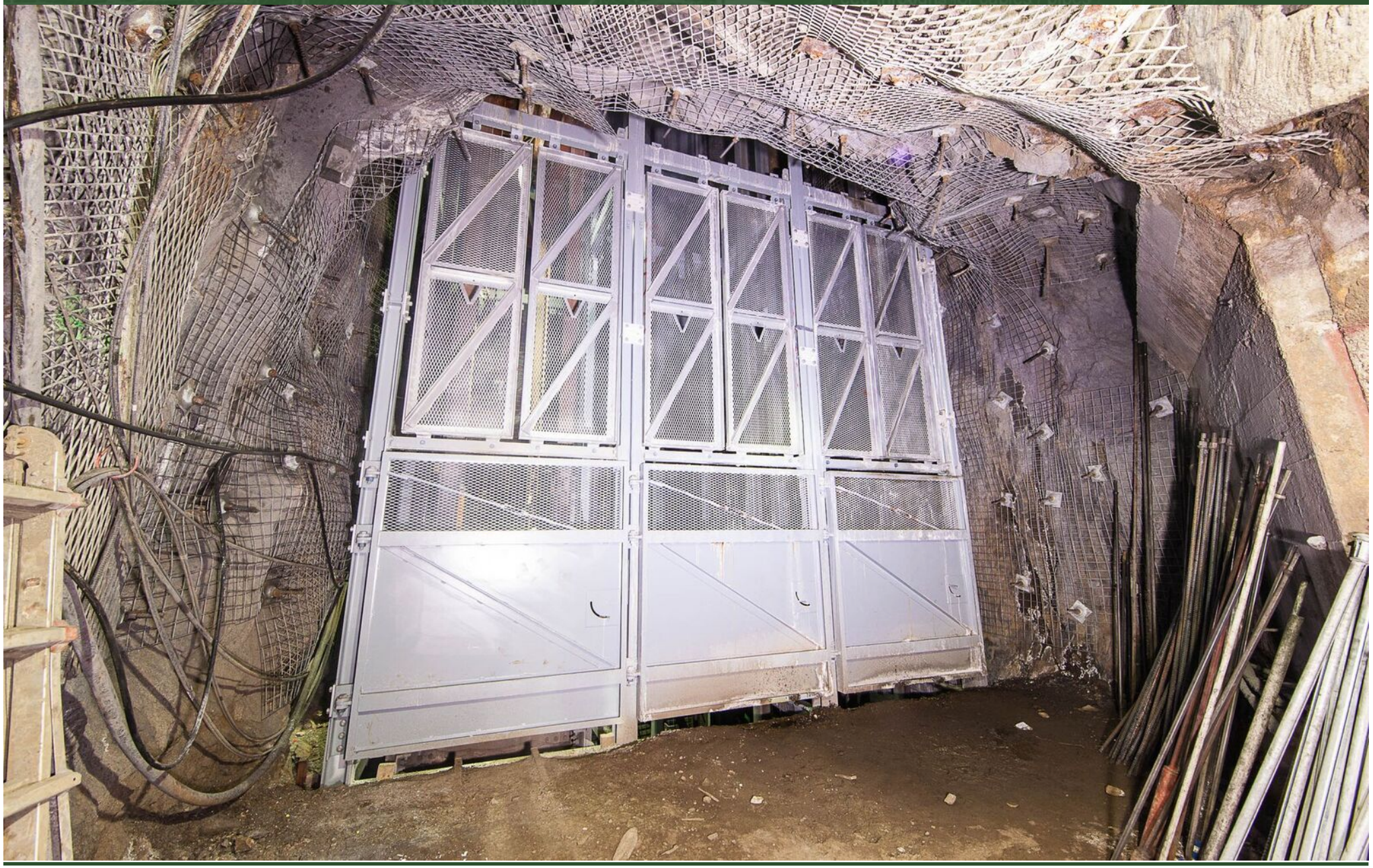


- Ross Shaft constructed in 1930s. Rehabilitation initiated in August 2012 to modernize the shaft for LBNF construction.
- SDSTA self-performing the project. Includes removal of old shaft steel and installation of ~6M pounds of new steel. Set to finish Q4 CY2017.
- Project total cost $32.2M: $5.95 in SD appropriated funds, $11.6M in U.S. DOE federal funds, and $14.6M in Sanford private funds.

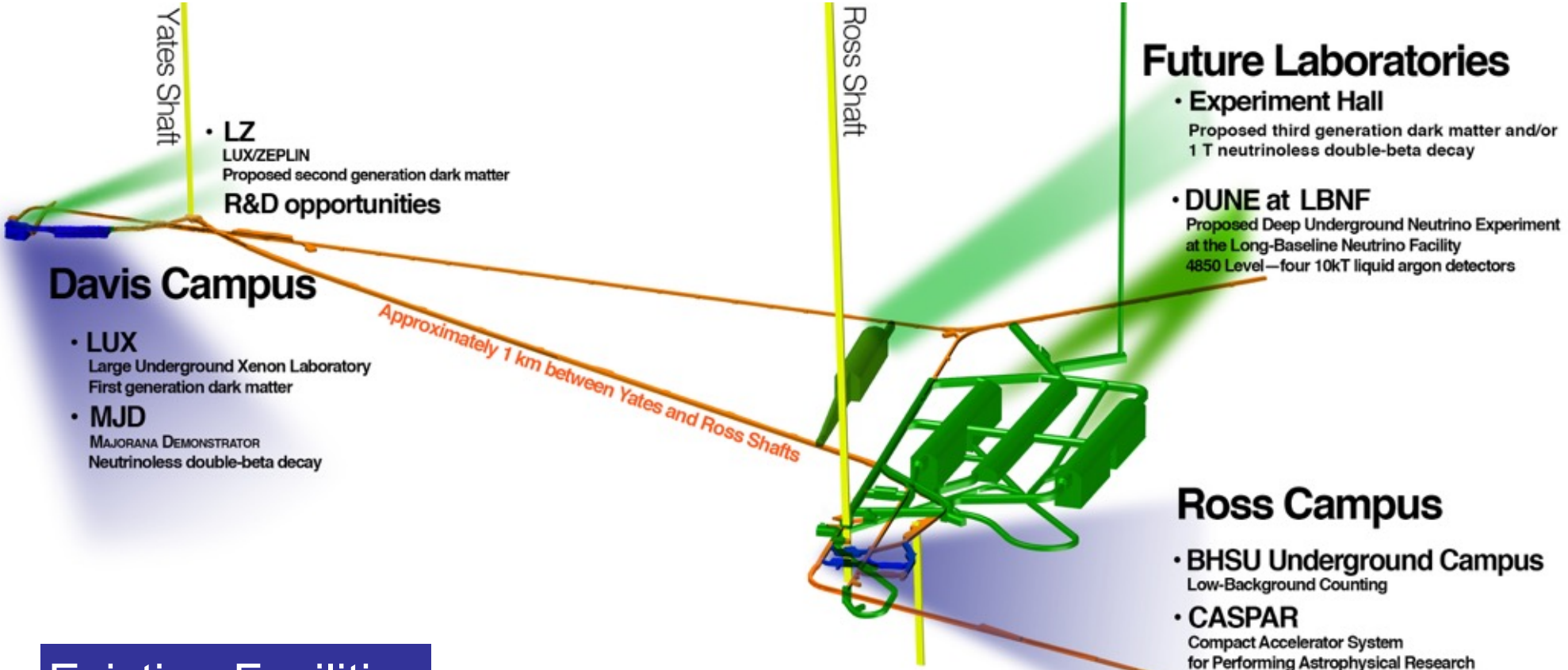


Ross Shaft Refurbishment Progress

4100L Station recently refurbished in late 2016



4850L Science Facilities



Existing Facilities

Future Facilities

Current Underground Physics Program

MAJORANA DEMONSTRATOR (MJD):

- Studying the neutrino's mass and the matter/antimatter imbalance in the universe. Proving the techniques needed for a tonne-scale experiment.
- 2 cryostats with 44 detectors (40kg Ge) assembled. Commissioning and testing underway. Physics data in mid-2017.

Large Underground Xenon (LUX):

- Direct detection of dark matter.
- Data taking completed in May 2016. Remains most sensitive DM experiment in world.
- Decommissioning underway in prep for the LUX-ZEPLIN (LZ) next generation experiment.

Current Underground Physics Program

Compact Accelerator System for Performing Astrophysical Research (CASPAR):

- Studying nuclear reactions in stars resulting in the generation of elements heavier than Fe.
- SDSM&T faculty and students leading assembly and commissioning process. Planning “first beam” by mid-2017.

Black Hills State University (BHSU) Underground Campus (BHUC):

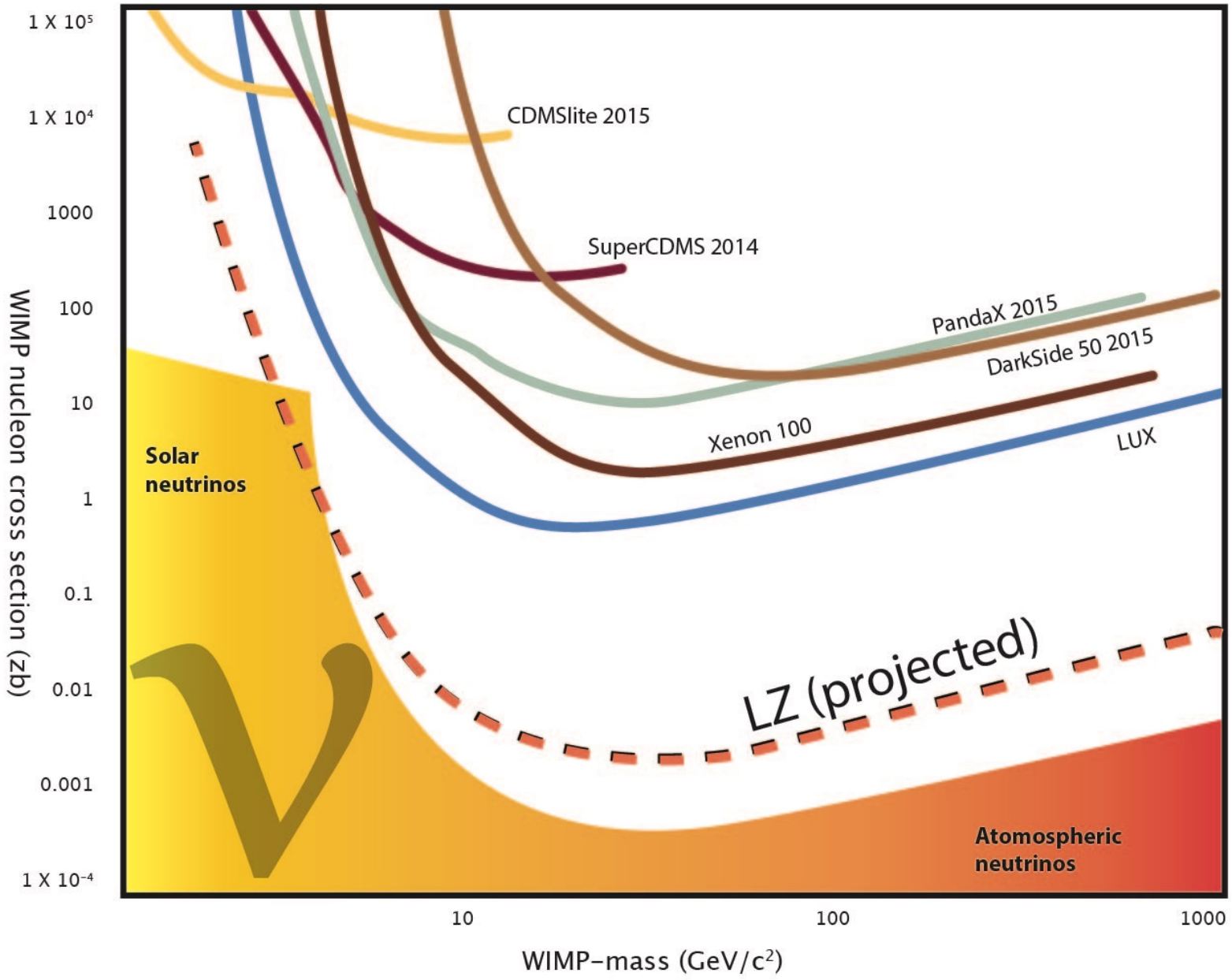
- Low background counting to characterize radiopurity of detector components.
- Installed 4 low background counters.
- Counting activities underway for the first 45 LZ photo multiplier tubes.
- Providing opportunities for undergraduates in physics and other science disciplines.

MAJORANA DEMONSTRATOR (MJD)

Cryostat assembly completed. Commissioning underway.

LUX-ZEPLIN (LZ) Dark Matter Experiment

Recent LUX result a 6X improvement over 2013. LZ will push limits further.



CASPAR

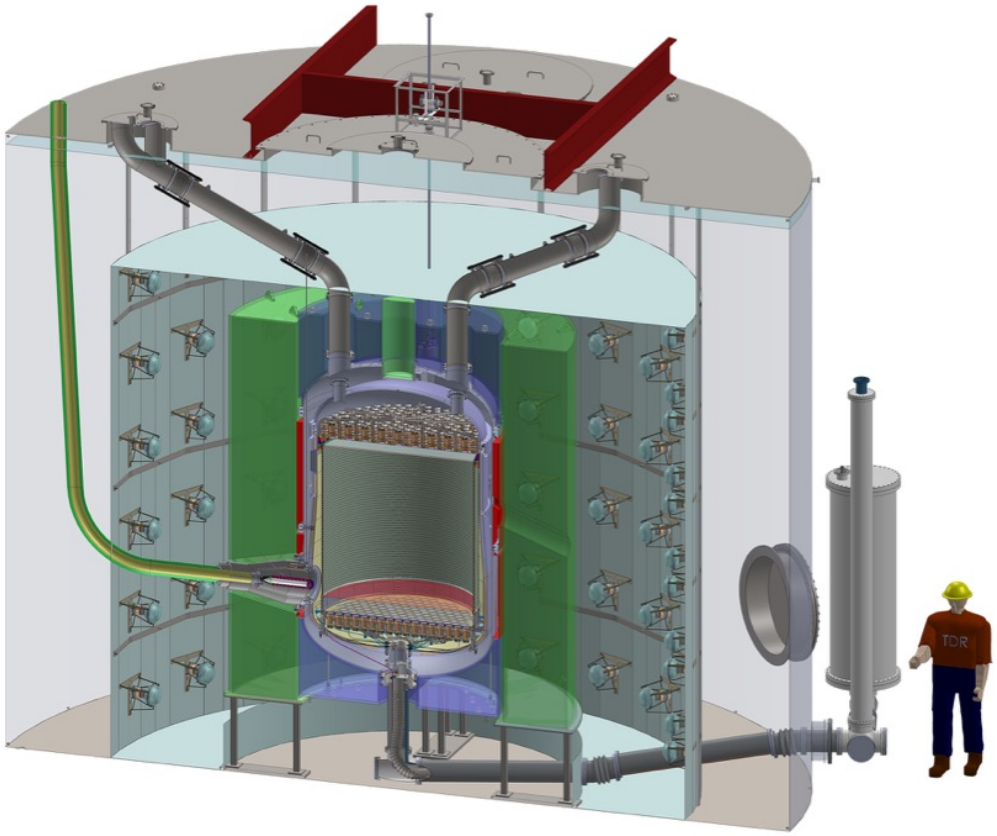
Assembly nearing completion. Commissioning underway.

BHSU Underground Campus

Establishing national-level capability for low-background counting

LUX-ZEPLIN (LZ) Dark Matter Experiment

LZ will be located in the Davis Cavern on the 4850 foot level

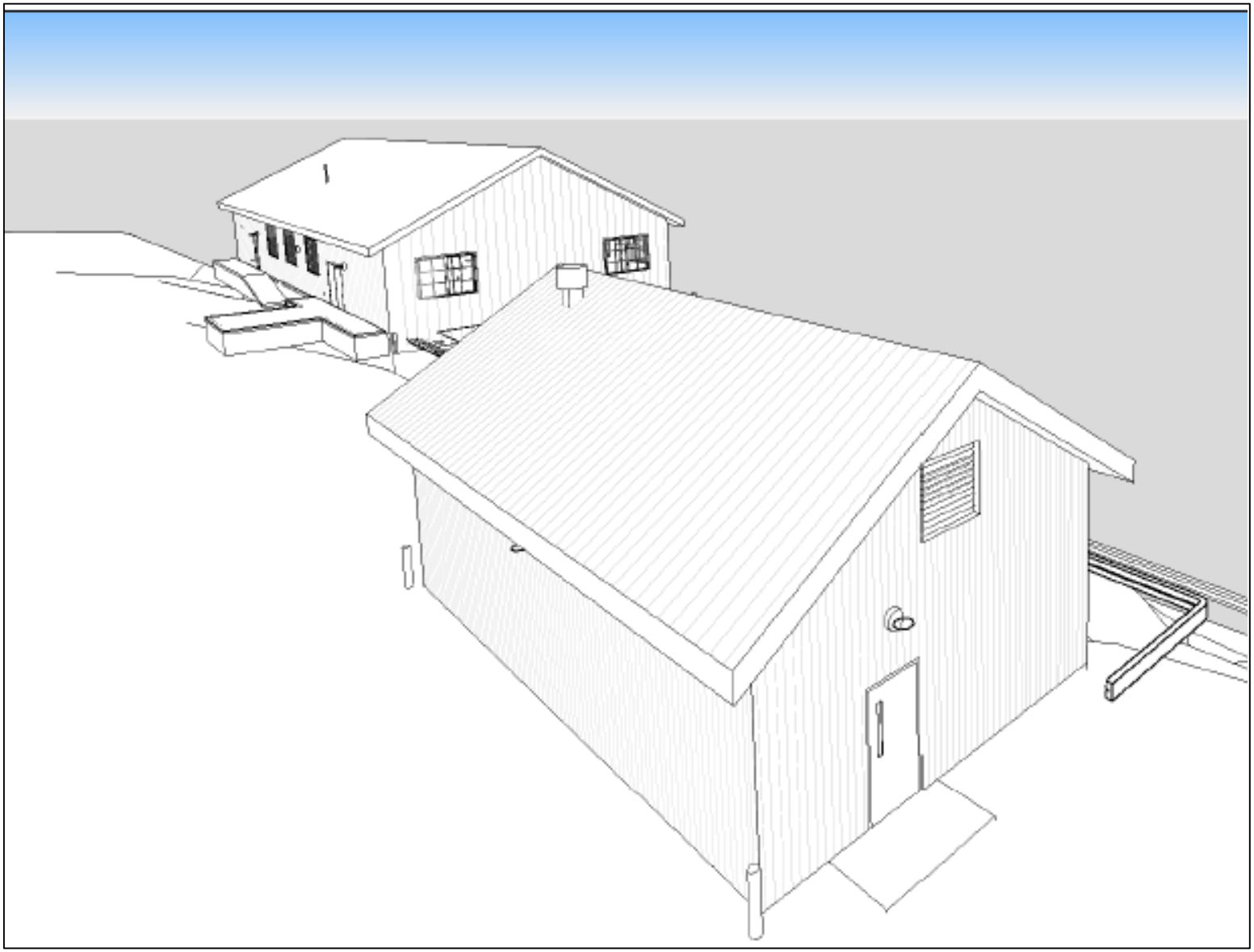


LZ Detector and Shielding

- 30x larger mass than the LUX experiment. 100x more sensitive.
- Lawrence Berkeley Lab leading experiment construction and ops.
- SDSTA modifying existing Surface Laboratory and Davis Campus to host LZ. Constructing new surface Radon Removal System bldg.
- Facility modifications to occur in 2016 (surface) and 2017 (4850L).
- Experiment design and construction work underway. DOE early construction approvals in hand.
- LZ experiment installation underground planned for 2018.
- 5 years of operations expected.

LZ Surface Facilities

New RRS Building in foreground. Existing Surface Laboratory in background.

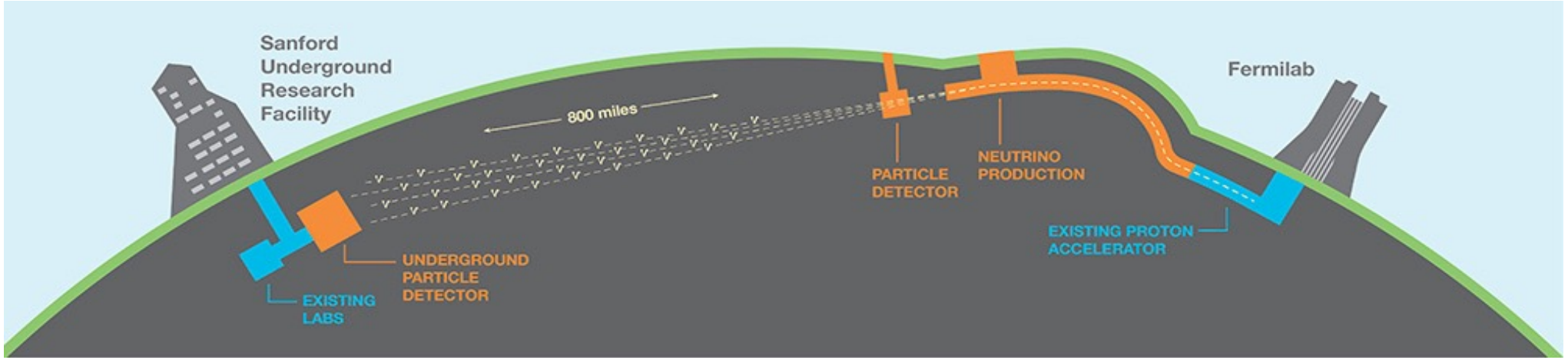


LZ Surface Construction

Surface facility construction to complete in May 2017

Long-Baseline Neutrino Facility (LBNF)

LBNF will host the Deep Underground Neutrino Experiment (DUNE)



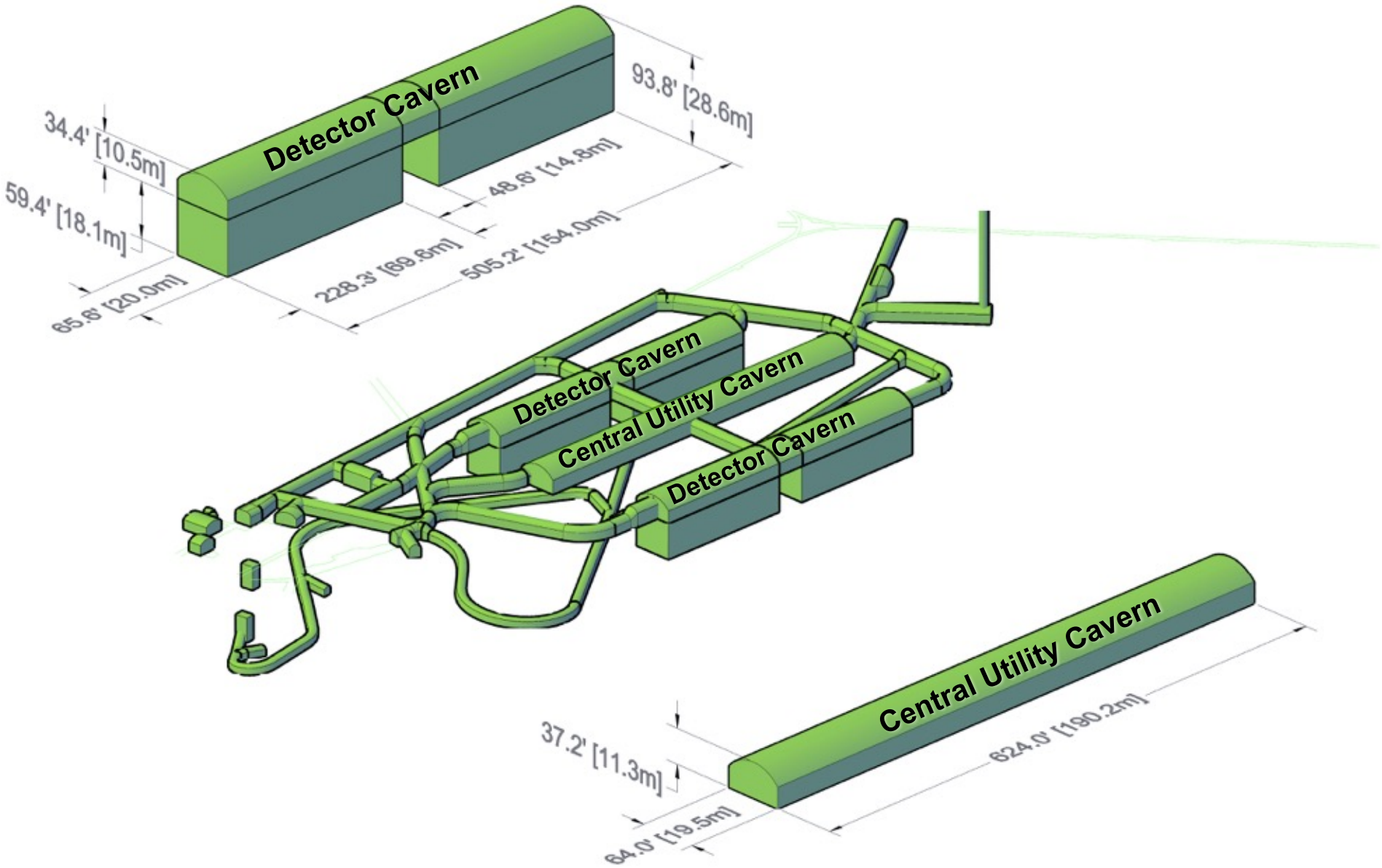
- DOE project led by Fermilab. Significant international contributions (including CERN).
- DUNE collaboration includes 956 scientists from 163 institutions and 30 countries.
  - Significant efforts underway at CERN on 2 prototype LAr detectors – called “protoDUNE”.
- Four DUNE detectors planned at SURF with 70kT liquid argon total (13 million gallons).
- DOE approved construction of SD facilities in Sept 2016. FY2017 appropriation pending.
- Construction in SD expected to start mid-2017. Excavation expected in 2019.
- Fermilab expects to have a Construction Manager under contract in spring 2017.
- LBNF/DUNE construction expected to last 10 years. DUNE ops planned for at least 20 years.

LBNF/DUNE Overview Video

https://www.youtube.com/watch?v=AYtKcZMJ_4c&t=2s

LBNF Excavations Planned for Sanford Lab

Excavated material ~800,000 tons (~500,000 cubic yards)



protoDUNE Progress at CERN

protoDUNE Progress at CERN

Economic Impacts in South Dakota

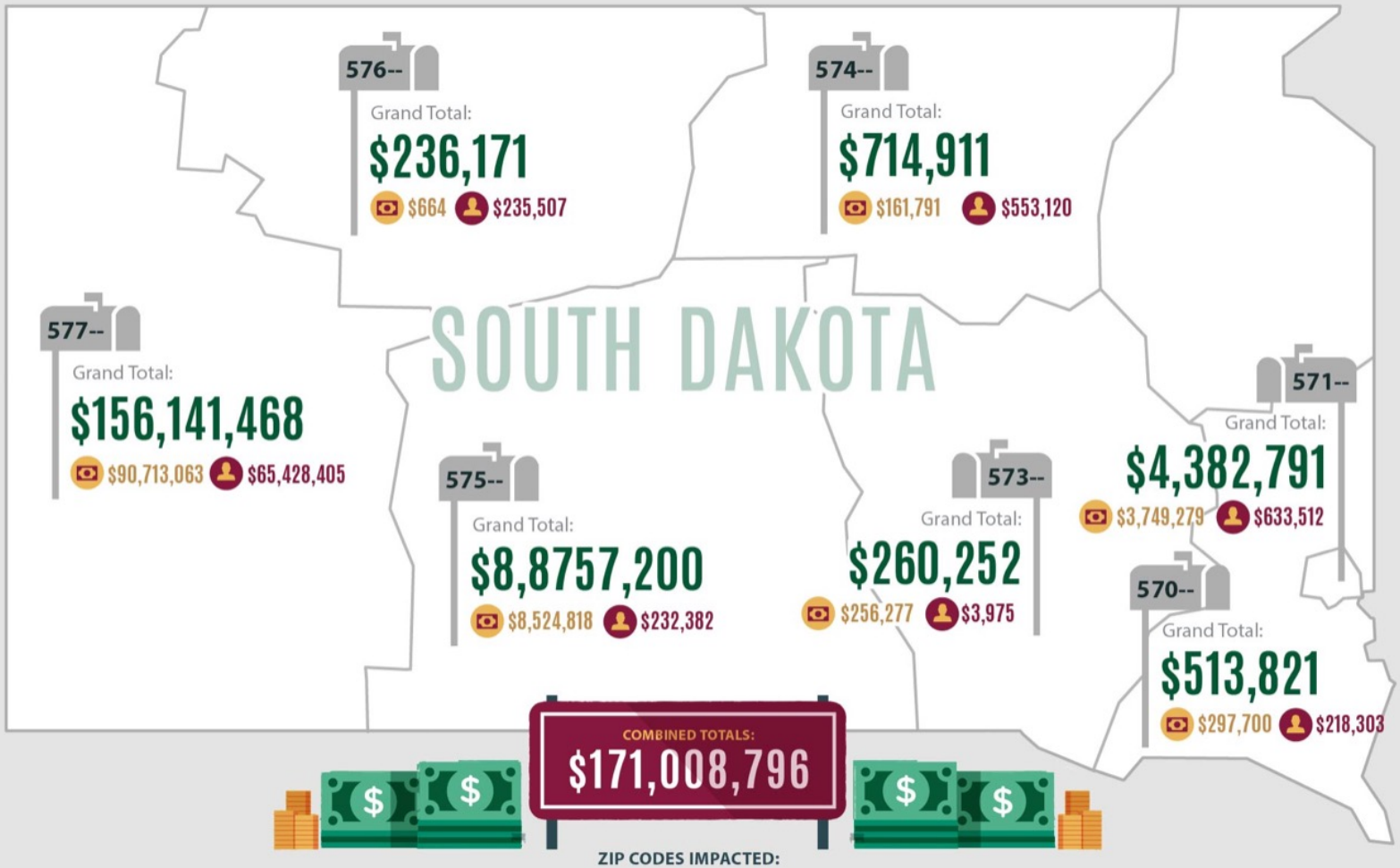
Through Year End CY2016

Spending in South Dakota to date	**$171M**
Annual total budget (all sources & activities)	$23.4M
Annual SURF operations budget (DOE funds)	$14.75M
Annual payroll in SD	$13.6M
Annual non-payroll expenses in SD	$5.9M
Jobs in South Dakota	163
Active research groups	24
Research groups with SD members	18

Sanford Lab's Economic Impact | IN THE STATE OF SOUTH DAKOTA

IMPACT DOLLARS SORTED BY FIRST THREE DIGITS OF ZIP CODE

TOTAL VENDORS PAID TOTAL SALARIES PAID



ZIP CODES IMPACTED:

570: 57005, 57006, 57007, 57013, 57017, 57022, 57032, 57038, 57042, 57069, 57071, 57078 • **571:** 57101, 57103, 57104, 57105, 57106, 57107, 57108, 57109, 57110, 57110, 57117, 57118 **573:** 57301, 57311, 57331, 57350, 57368, 57369, 57373, 57374 • **574:** 57401, 57402, 57445, 57456, 57465, 57469 • **575:** 57501,57532, 57544 • **576:** 57620 • **577:** 57701, 57702, 57703, 57706, 57709, 57717, 57718, 57719, 57722, 57730, 57732, 57735, 57744, 57745, 57747, 57751, 57752, 57754, 57759, 57760, 57761, 57769, 57779, 57783, 57785, 57787, 57788, 57793, 57799

Projected LBNF/DUNE Economic Impact

Economic Impact of the Long-Baseline Neutrino Facility

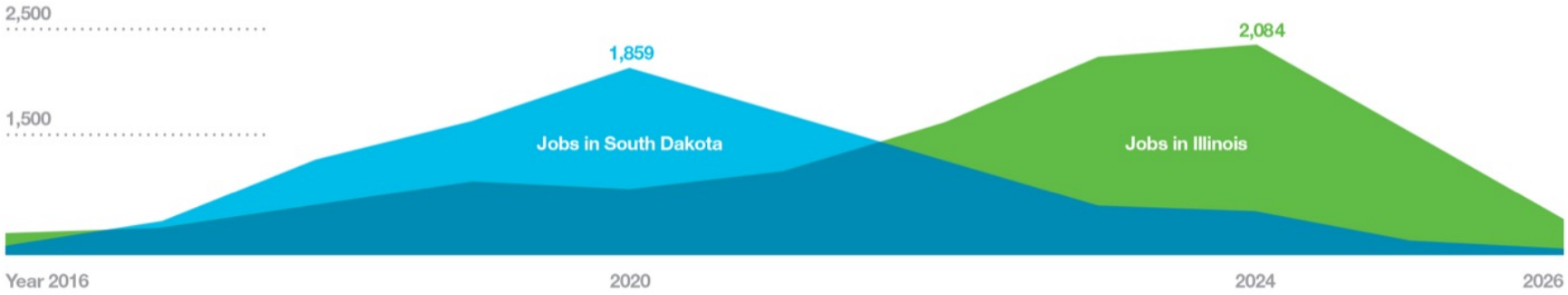
Economic impact, 2016-2026*

South Dakota		Illinois	
$952 million	**$340 million**	**$1,204 million**	**$593 million**
Total economic output	Income for South Dakota households	Total economic output	Income for Illinois households

90% of economic output is in the 13-county western South Dakota region

94% of economic output is in the 9-county Chicago metro region

Jobs created, 2016–2026*



Full report available at: http://lbnf.fnal.gov/economic-impact.html

Education and Outreach Impacts

2008 through 2016

K-12 students participating in programs	15,451
Teachers participating in programs	2,697
General public attending programs	19,210+

SD University Involvement Highlights

	BHSU	• Joint Sanford Science Education Center with SDSTA. Remodel of the Jonas Science Hall was completed in October 2015. • BHSU leads Sanford Lab education and outreach activities. • Joint development and operation of the BHSU Underground Campus on 4850L.
	DSU	• DSU leads *Center for Theoretical Underground Physics and Related Areas* (CETUP) conference. (2016 program was be the 6th year held. Over 200 participants and many publications).
	SDSM&T	• SDSM&T and USD are lead SD institutions for physics PhD program. • SDSM&T has 19 physics PhD students. 11 involved in SURF projects. • 11 faculty members in Physics Department. 6 of them working on SURF projects (DUNE, CASPAR, LUX, LZ and MAJORANA DEMONSTRATOR). • SDSM&T faculty in leadership roles for DUNE, CASPAR, LZ and MAJORANA. • In May 2015, SDSM&T held first science conference on *Science at the Sanford Underground Research Facility.* • SDSM&T has 2 Master's Students (1 involved with SURF projects), also 52 undergraduate physics students with many involved in SURF related research.
	SDSU	• SDSU collaborating with DUNE scientists on liquid argon fluid flow and purity modeling through the DUNE detector cryostat.
	USD	• USD and SDSM&T are lead SD institutions for physics PhD program. • USD has 3 scientists involved in SURF projects. • SDSTA scientist enrolled in PhD program at USD.

Educational Opportunities for K-12 Students

School Presentations

Elementary
- A Day in the Life…
- Particle Accelerators

Middle School
- Career Opportunities
- Dark Matter

High School
- Neutrinos

Curriculum Units

Elementary
- Exploring Unseen
- Force Be With You

Middle School
- Seismic Science
- Search Dark Matter

High School
- Perplexing Puddles
- Star-Stuff

In Development
- There & Back Again
- Waterworks

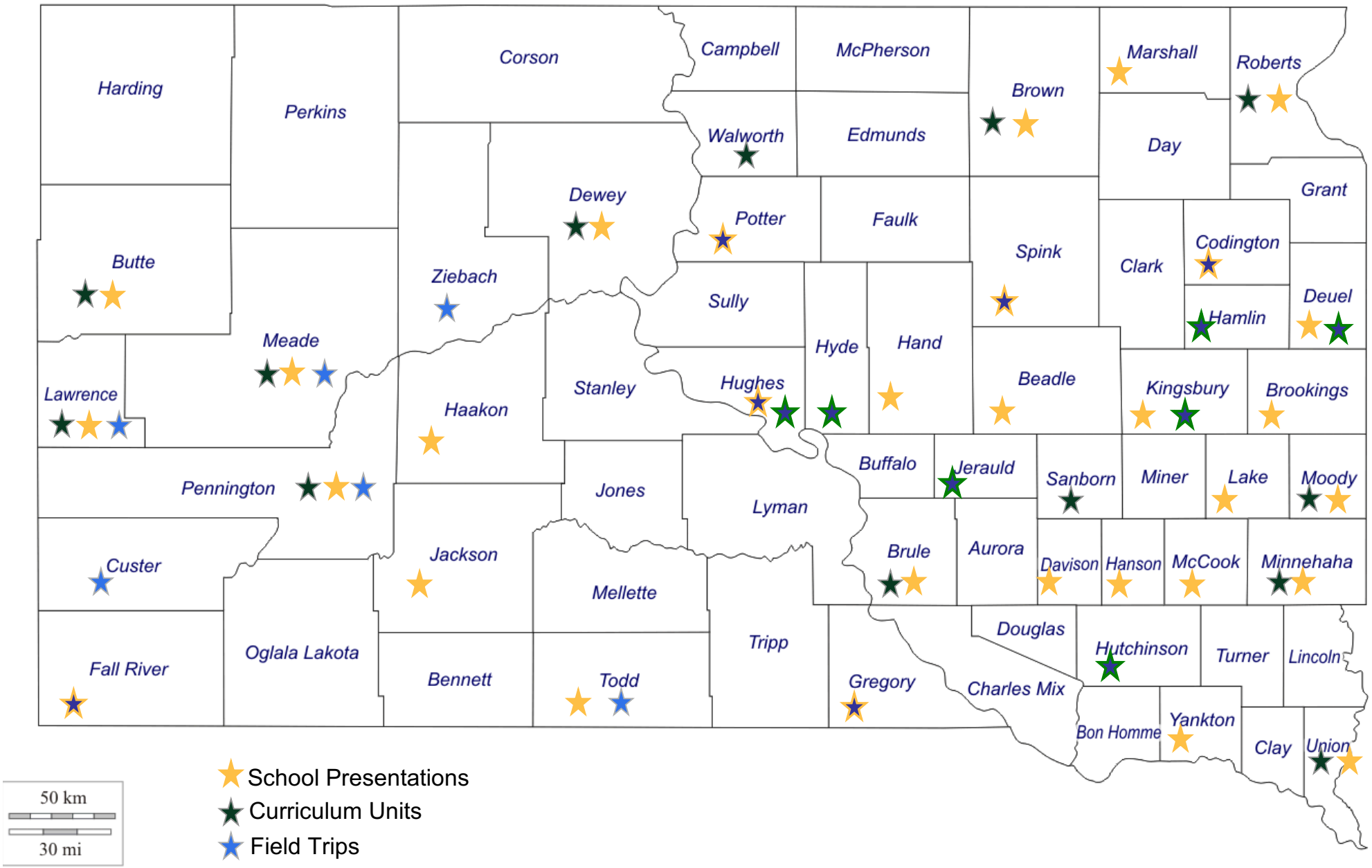
Field Trips

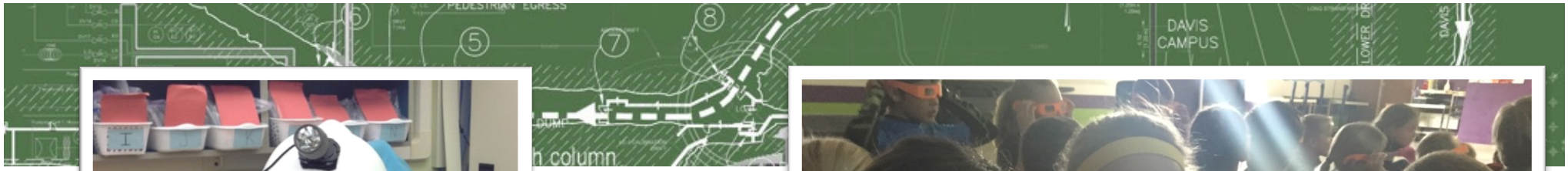
Opportunities to visit the lab are limited. School visits available:
- Fall
- Spring

E&O Results - June 2015 to present

Activity	Number of Students
School Presentations	11,516
Curriculum Units	1,637
Field Trips	885

E&O Reach in South Dakota Schools




DAVIS
CAMPUS


NORTH DAKOTA


DAVIS CAMPUS
EXHAUST DRIFT
CHILLER
LN bath column
Feed-throughs for cables / pipes

Thank You!

DOE Operations Funding Ongoing Today

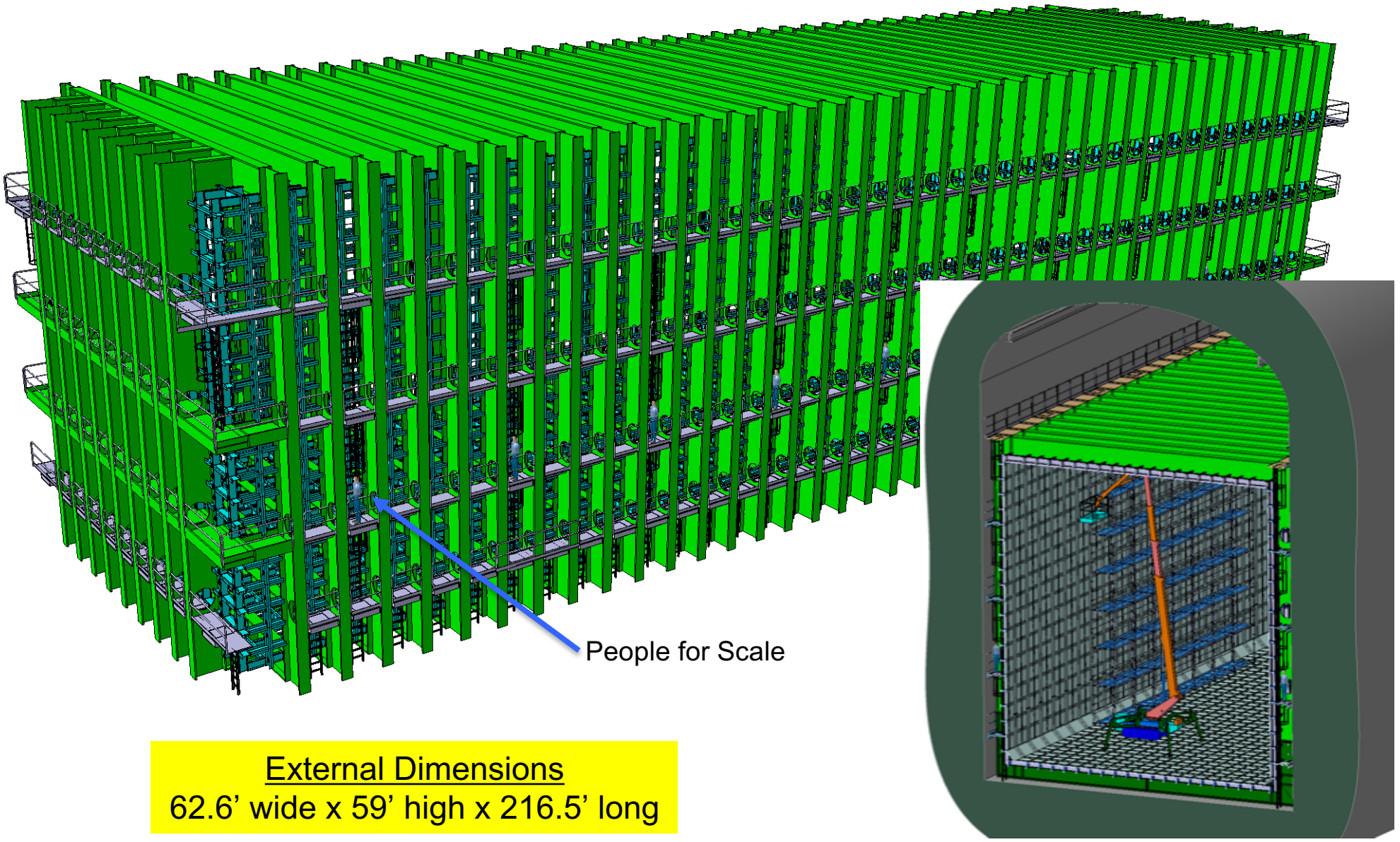
- Through LBNL:
  - Federal FY2012* - $11M (SDSTA allocation $9.3M)
  - Federal FY2013 - $14M (SDSTA allocation $12.97M)
  - Federal FY2014 - $15M (SDSTA allocation $13.4M)
  - Federal FY2015 - $15M (SDSTA allocation $13.5M)
  - Federal FY2016 - $15M (SDSTA allocation $13.9M)
  - Federal FY2017** - $15M (SDSTA allocation $14.75M)

* FY2012 was a transition year from NSF to DOE operations funds. NSF funded first four months due to a continuing resolution.

** In FY2017, under continuing resolution, assuming level funding.

LBNF Free-Standing Steel Cryostat

CERN leading Cryostat design and development



External Dimensions
62.6’ wide x 59’ high x 216.5’ long

Maintenance Shop Conceptual Design

Defining future maintenance facility for Sanford Lab operations

Maintenance Shop Conceptual Design

Maintenance Shop Conceptual Design

Maintenance Shop Conceptual Design

E&O Building Conceptual Design

Defining future Education & Outreach Facility

E&O Building Conceptual Design - Exterior

E&O Building Conceptual Design

Alternate to provide additional science and engineering collaboration facilities